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Huli oral health

PAUL L. NEWELL[1]

Mullumbimby, New South Wales, Australia

SUMMARY

The Tari oral health study was conducted in 1985 and aimed to provide an oral health profile of a rural highlands community. The sample was selected from the database of the Tari Research Unit, Southern Highlands Province, Papua New Guinea and consisted of 815 Huli people aged from 3 to 64 years, in seven age groups, who were examined for oral health status and had completed an interview-questionnaire. A wide range of oral health status was seen, ranging from excellent to very poor. Dental caries and periodontal disease were common in the population. Oral habits such as smoking and betelnut chewing were associated with an increase in leukoplakia, which may lead to oral cancer in some people. Dental caries varied in prevalence and severity. Higher decayed, missing and filled teeth scores in the primary teeth of young children were associated with defective tooth formation (hypoplasia) linked to maternal and childhood illnesses and nutritional deficiencies. Older adults had the worst oral health, with the 45-64 year old group having a caries prevalence of 95% and a decayed, missing and filled teeth score of 14.7. Root surface caries, seen as a consequence of poor oral hygiene and gum recession, was the major site of caries attack in the older Huli. The public oral health services are unable to reach a large proportion of the rural population, and people continue to use traditional herbal and folk remedies. Many seek the skills of local tooth extractors who use six-inch nails with no anaesthetic.

Introduction

The oral health status of the majority of Papua New Guineans is unknown. Current trends and recent interviews with workers in the field suggest that the oral health of the majority of the people is worsening (1). Dietary change and the popularity of betelnut continue to cause ill-health in the population. The full impact of these changes will be evaluated by the forthcoming National Oral Health Survey of Papua New Guinea (PNG) (Dr Bais Gwale, National Department of Health, personal communication).

Tooth decay and gum disease are sometimes painful and annoying, but usually not life threatening. Oral cancer is devastating but rare. Most oral diseases are preventable, and "the challenge is to empower individuals, families and communities to take responsibility for their own health" – National Health Plan 2001-2010 (2). Recent statistics from the Western Pacific Region show that PNG is rating poorly in key indicator areas of health. Mortality rates for infants and mothers and life expectancy are the worst in the region (2). Successive governments have placed dental and oral health programs low on the list of health priorities due to factors such as limited resources and high levels of other illness that need to be attended to.

The small amount of previous research on the oral health of Papua New Guineans shows a wide range of conditions across the country. Highland and urban populations have the most tooth decay, and the overall prevalence of periodontal (gum) disease is higher than in most western countries (3, reviewed in 4).

Between March and August 1985 an oral

[1] Dental Practitioner, PO Box 183, Mullumbimby, New South Wales 2482, Australia
Formerly, Lecturer in Dentistry, University of Papua New Guinea and Research Associate, Papua New Guinea Institute of Medical Research

health survey was conducted in the Tari District, Southern Highlands Province (SHP). The main aim of the study was to provide an oral health profile of a rural highlands community. This paper presents the main findings.

The Tari oral health study

The three objectives of the Tari survey were:

1. To measure the prevalence and severity of oral diseases and their treatment needs.

2. To evaluate environmental, social and economic factors which affect oral health status and attitudes in seeking oral health care.

3. To describe the type and availability of dental services, both traditional and modern, and to evaluate the extent to which they satisfy the oral health needs of the study population.

The Tari region was chosen for this study because the region had:

- a large and ethnically homogeneous population subsisting mainly on sweet potato, with only recent and minimal changes towards a western diet

- limited availability and access to modern dental treatment

- an excellent surveillance infrastructure which had been developed by the Tari Research Unit (TRU) since 1970, with demographic, health status and environmental data covering a surveillance population of about 27,000 people

- a high level of tooth defects in the primary teeth of children which had been reported in an earlier anthropometric survey (Dr G. Roberts, personal communication).

Methods

Sample selection consisted of a multistage cluster sample based on families with children 6 or 12 years old contained in the TRU database. These are indicator age groups for the global monitoring of caries.

Stage one of the sample frame involved the random selection of census units in three 'environmental zones', chosen to provide a broad range of geographic, socioeconomic and health-related parameters (5-7).

Stage two involved the selection of a minimum of 120 persons in seven age groups with age range 3-64 years, clustered around the 6 and 12 year olds, divided between the environmental zones.

I made a total of 871 oral examinations which were recorded by the dental therapist field assistant Mr Fabian Yapa. The dental team was assisted by TRU reporters who acted as interpreters and arranged for the subjects to attend one of 19 examination sites. The reporters provided invaluable logistic support, and strongly influenced the achievement of a good response rate. A total of 6% of the sample underwent repeat examination.

Examinations were conducted in natural light using a basic instrument kit. Internationally recognized criteria were used for most of the oral conditions investigated (8). Subjects were advised of their oral health status, and treatment or referral offered if necessary. A total of 149 patients were treated by the survey team, mostly for tooth extraction. Some fillings were placed using silver fluoride and glass ionomer cement with no anaesthetic or drill, employing a 'minimum intervention' approach.

Before the oral examination each person (or in the case of children a parent or guardian) responded to a short interview-questionnaire. This recorded information on 15 groups of variables including socioeconomic and demographic data, perceived oral status and past dental treatment, dietary variables, oral hygiene practices, oral habits, drinking water source, and knowledge of traditional practices related to oral diseases and their prevention.

The data presented in this paper are based on the 815 subjects who completed both the examination and questionnaire, and are derived from a treatise on Huli oral health submitted to the University of Sydney (4).

Results

Sample

The sample characteristics with respect to socioeconomic status and occupation are similar to those described by Vail in the TRU socioeconomic survey (7). Over 70% were subsistence farmers or their children. The ratio of males to females (424:391) is well balanced throughout the seven age groups, although the 45-64 year age group shows the greatest bias with a male-female ratio of 69:37. The data for males and females have been combined for this paper.

General picture: main findings

A wide variety of oral health status was seen, ranging from excellent to very poor. Most people did not clean their teeth on a regular basis, and consequently oral hygiene was poor, with plaque, calculus (hard mineralized deposits around the necks of teeth) and food debris present on the teeth. Nearly everyone had bleeding gums (gingivitis).

There was a high prevalence of untreated tooth decay (caries) and nearly 15% of the sample needed emergency treatment for badly decayed, painful or infected teeth. Almost no fillings were seen, and the only treatment that the majority of people had received was tooth extraction, either at Tari dental clinic or by local 'traditional practitioners'.

Many young children had defectively formed (hypoplastic) primary teeth. Some of these were blackened, broken down and abscessed due to caries which had subsequently attacked these susceptible teeth.

In the permanent dentitions of adults, high levels of attrition (tooth wear) were seen when compared to western populations. This involves the progressive wearing away of the biting surfaces of the teeth, caused by vigorous chewing of tough foods, sugar cane, and grit and ashes incorporated into food during preparation and cooking. Attrition is held by some authorities to be a natural and beneficial process in populations eating an unrefined and coarse diet. Attrition was an important influence on the pattern and progression of caries among the Huli.

Progressive periodontal (supporting tissues of the teeth) disease was common and increased in prevalence and severity with age. Once the root surfaces of teeth are exposed to the oral environment (as a consequence of periodontal disease) there is a tendency for large amounts of food debris and plaque to accumulate around the necks of the teeth. In the absence of effective oral hygiene, sweet potato residues are converted to acid by the action of saliva, and can break down the softer root surfaces, leading to caries. The frequent consumption of sugar cane also provides the oral bacteria with ample supplies of sugar to be converted into acid. Root surface caries was the most common type of caries seen in the older people.

Over a lifetime, nearly everyone had suffered from some degree of periodontal disease, and most of those examined had been affected by tooth decay. Even so, the vast majority of the sample had retained most of their teeth until well into old age. In the 45-64 year age group the average person had 23 out of a possible 32 teeth present, and nearly 80% of this age group had 20 or more teeth present. Undoubtedly the limited availability of treatment (ie tooth extraction) services contributed to this high level of tooth retention, and many people had teeth which were so badly broken down that only the roots remained. Even so, these retained roots sometimes persisted as functional units in the dentition, and were an important feature in maintaining the bony architecture of the jaws. Only 3 out of the total sample of 815 people had no teeth, and these were older males who had full dentures (false teeth).

Other oral diseases were less common. About 5% of the total sample had abscesses or sinuses associated with infected teeth. The youngest age groups had the highest prevalence of abscesses (about 10% of all children aged 3 to 6 years). This was associated with the higher prevalence of badly decayed teeth in these children. Conditions associated with betelnut chewing and smoking habits (mostly practised by adult males) were seen, and these presented as white patches (leukoplakia) on the inside of the cheeks, or 'smoker's palate' in the roof of the mouth. Orthodontic problems (irregularly spaced teeth

or impacted wisdom teeth) were seen in 8% of the sample, and were of minor public health importance.

Dental caries

The significance of dental caries was measured by the prevalence of people with one or more carious teeth (Table 1) and the Decayed, Missing and Filled Teeth index (DMFT for permanent teeth/dmft for primary teeth). For people 30 years and older the Missing component of the DMFT records teeth missing for any reason including trauma and periodontal disease (8). The grouping of all teeth lost into one category is practical at a clinical and survey level because older adults are not always clear whether a tooth lost years previously was due to caries or periodontal disease. However, with the World Health Organization (WHO) indices and recording criteria in use at the time of the survey, it was difficult to measure the real reasons for tooth loss in the population.

The natural history of dental caries in the study population

Primary teeth

The DMFT and dmft scores for children and adolescents (Tables 2 and 3) show that caries of the primary teeth was a more serious problem than in the permanent dentition. By the age of 6 years, the mean dmft score was nearly 3 teeth (Table 3), which represented 20% of the primary teeth present. The frequency distribution of dmft scores showed that 25% of the 6 year olds had 5 or more decayed teeth per child, and only 32% of this age group had no tooth decay (caries-free) (Table 1). This low percentage of caries-free children compared unfavourably with the WHO Global Goal for the year 2000, of 50% of 5-6 year old children to be caries-free (9). The strong association between high dmft scores and the prevalence of tooth defects (hypoplasia) was an important finding in this study and is discussed later.

Many children were miserable because of toothache, and during the interview nearly 40% of the 6 year olds complained of pain or holes in the teeth. The usual treatment in Tari was aspirin or penicillin injections at the aid post.

TABLE 1

PREVALENCE OF CARIES BY AGE GROUP

Age group (years)	Sample	Percentage of subjects with one or more carious teeth
3-5	104	46
6	112	68
12	121	45
15-19	120	58
20-29	115	82
30-44	137	86
45-64	106	95
All ages	815	69

Note: in age groups 3-5 years and 6 years the primary teeth only are recorded here

There had been no extractions for decayed primary teeth. The mothers were not unduly concerned, since they anticipated better luck with the permanent dentition.

Permanent teeth

With the natural loss of the primary teeth, the Huli dentitions passed through a period of good oral health with low caries rates. At age 12 the average child had one decayed permanent tooth (Table 2). This compared well with the Global Goal of 3 DMFT by the year 2000 (9), and placed Tari children in the very low (0.0-1.1 DMFT) caries prevalence group by international standards (10).

DMFT scores increased with age (Figure 1) but remained in the low caries range until the age of 45 years. In the 45-64 year age group the DMFT score was much higher at nearly 15 teeth per person (full dentition = 32 teeth). More than half of this score was due to missing teeth, extracted or lost because of caries, periodontal disease or other reasons (Table 2 and Figure 1). No fillings were seen in this age group. Only 5% of people in the 45-64 year age group were caries-free, and over half complained of pain or holes in the teeth during the interview.

TABLE 2

DENTAL CARIES AND PERMANENT TEETH PRESENT: MEAN SCORES BY AGE GROUP

Age group (years)	N	Teeth present		Decayed		Missing		Filled		DMFT	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3-5	104	0.82	2.3	0.02	0.2	0.00	0.0	0.00	0.0	0.02	0.2
6	112	8.42	3.7	0.46	0.9	0.00	0.0	0.00	0.0	0.46	0.9
12	121	26.3	3.1	1.04	1.5	0.04	0.2	0.00	0.0	1.08	1.6
15-19	120	28.8	2.0	1.53	2.3	0.24	0.7	0.13	0.6	1.90	2.5
20-29	115	30.3	2.2	2.68	2.9	0.97	1.6	0.27	0.8	3.92	3.9
30-44	137	28.7	4.3	2.72	3.3	3.01	4.3	0.01	0.1	5.74	6.2
45-64	106	23.4	7.9	6.11	4.8	8.62	7.9	0.00	0.0	14.73	8.8
Total	815	21.5	11.2	2.07	3.2	1.81	4.4	0.06	0.4	3.94	6.4

SD = standard deviation

TABLE 3

DENTAL CARIES AND PRIMARY TEETH PRESENT: MEAN SCORES BY AGE GROUP

Age group (years)	N	Teeth present		decayed		missing		filled		dmft	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3-5	104	19.69	1.5	1.84	2.7	0.00	0.0	0.00	0.0	1.84	1.5
6	112	14.94	3.6	2.85	3.3	0.07	0.4	0.00	0.0	2.92	3.4
Total	216	17.23	3.7	2.36	3.1	0.04	0.3	0.00	0.0	2.40	3.1

SD = standard deviation

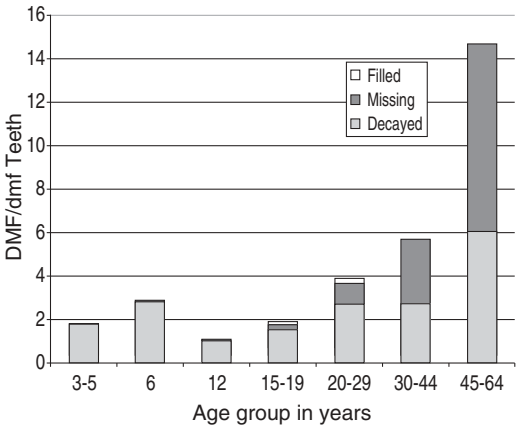

Figure 1. Mean DMFT/dmft by age group in Tari: Decayed, Missing and Filled Permanent (DMFT) and Primary (dmft) Teeth. For age groups 3-5 years and 6 years, only the primary teeth (dmft) score is given.

Diet, attrition and the pattern of caries attack in the permanent dentition

The pattern of caries attack and the age group-specific DMFT scores suggest that the natural history of tooth decay in Tari was different to that found in most western populations.

Diet

The staple food of the traditional Huli diet is sweet potato, roasted or baked in the fire, and green vegetables. The diet is occasionally supplemented with pig meat and, when money is available, introduced foods from the trade store such as rice, tinned fish, biscuits, soft

drinks and sugar. Sugar cane was used by almost everyone as a thirst quencher, and carried instead of water.

The consumption of soft refined foods with high sugar content is widely believed to be responsible for the rapid increase in caries in populations changing from traditional to western diets (11). In western populations with high sugar consumption, sugary soft drinks and in-between-meals snacking, caries is a disease of children and adolescents. The peak of caries activity occurs 2-4 years after the appearance of the tooth in the mouth. If teeth survive this initial attack, then they become more resistant to caries with increasing age. This is due to the protective factors in saliva and some foods, and to maturation of the mineral composition of the teeth (12).

In Tari, caries was infrequently found in the occlusal fissures of molars or interproximal surfaces (the biting and in-between surfaces of the teeth) in the younger permanent teeth. In contrast, these are the most common sites of attack in western populations.

Attrition (tooth wear)

With increasing age, the potential stagnation sites in occlusal fissures and interproximal areas where food and plaque tend to accumulate are worn away due to attrition (tooth wear) caused by vigorous chewing of tough, fibrous or gritty foods found in a natural unrefined diet. These worn surfaces were smooth and self-cleansing, and thus less susceptible to caries. Vigorous mastication also stimulates salivary flow, which helps protect against caries.

The attrition rate was high. By 12 years of age over 70% of subjects showed signs of tooth wear in the enamel surface. In the 30-44 year age group 80% of subjects had teeth worn down to the underlying dentine. Of those aged 45-64 years nearly half had back teeth which were completely flattened and smooth, with obliteration of the cusps and fissures. The process is gradual and painless. Continuous eruption of the teeth and their supporting tissues, and secondary dentine deposition inside the tooth to protect the nerve are physiological responses to tooth wear in the natural dentition.

This functional wearing-in of the dentition produces ideal free-sliding grinding surfaces and was an important feature in the dentitions of early humans as shown by archaeological evidence (13). Attrition rates in Tari were similar to those found in Aboriginal Australians before they adopted western food habits (14). If tooth wear is too rapid, it can lead to exposure of the pulp chamber, infection and abscess formation. This extreme situation was not encountered in the Tari sample, but evidence from other parts of PNG (3) indicates higher attrition rates with older people in coastal areas, probably linked to betelnut chewing. This 'overuse' of the dentition exceeds the compensatory mechanisms mentioned above, and a worn-in dentition can become worn-out.

However, although most permanent teeth were spared the early and devastating pattern of caries attack found in many western populations, caries became a more serious problem in later life in the form of root surface caries.

Root surface caries

Root surface caries was seen as a consequence of poor oral hygiene, chronic periodontal disease with gum recession, and exposure of the softer more susceptible root surfaces to the oral environment. The decay usually progresses slowly and painlessly and is not noticed by the sufferer because the holes are usually filled with food debris and located at or below the gum margin. Eventually some teeth become so undermined that they fracture away during chewing. At this stage the decay process stops, because the surfaces of the remaining roots are then exposed to the protective and remineralizing properties of saliva. Many older Huli had a number of these root stumps in their jaws, and were still able to chew with them.

Root surface caries usually started after 20 years of age, and by 30-44 years 45% of the total DMFT score was due to root caries. In the 45-64 year age group the prevalence of root caries was 74%, with an average of 2.4 teeth per person affected. If the root remnants seen as a consequence of root caries in older subjects were included in the mean root caries

score, then the percentage of decay attributable to root caries would have been much higher.

Tooth treatment requirements

Treatment needs assessment describes the type and amount of treatment needed to make a person dentally fit. The treatment needs were extensive, indicating the general lack of oral health care received (or sought) by the population. The type of treatment needed was recorded using WHO criteria, with consideration of the basic techniques and materials available in Tari in 1985.

Treatment needs were graded into those needing immediate treatment for severe pain or infection, and those in need of fillings or extractions to render them dentally fit.

The previous section on dental caries indicated that caries in primary teeth and on root surfaces of older people were significant problems. Table 4 shows that the prevalence and severity (mean number of teeth needing treatment per subject) of dental disease, mostly caused by caries, becomes greater with the age of the primary and permanent dentitions.

Immediate treatment

A total of 117 people needed immediate care, mostly for tooth extraction because of severe pain or infection (93%).

Abscesses and badly decayed teeth were common in the primary teeth of children aged 3-6 years, with about 13% of this age group needing immediate care. The 45-64 year age group had the highest percentage of people needing immediate care (22%). The ranking of conditions needing immediate tooth extraction in this age group were: severe pain or abscess due to caries (68%); periodontal disease (18%); not specified (14%).

Fillings and extractions needed

The need for fillings represented those teeth which could be adequately restored using simple methods such as the minimum intervention or atraumatic restorative technique (ART) (15). If decay had destroyed a tooth to the extent that it could not be restored, or only the roots remained, then the tooth was recorded as needing extraction because of caries.

Nearly 60% of the total sample needed fillings, and 36% needed extractions (Table 4). Over the whole sample of 815 people, 1363 fillings and 947 extractions were needed.

The scale of the problem can be illustrated by considering that in 1985 one dental orderly was providing dental services to Tari and adjacent census divisions in Koroba and Nipa census districts, with an estimated catchment population of 86,000. The attendance book at

TABLE 4

TREATMENT NEEDS: PERCENTAGE OF SUBJECTS AND MEAN NUMBER OF TEETH PER SUBJECT NEEDING FILLINGS OR EXTRACTIONS, AND PERCENTAGE NEEDING IMMEDIATE CARE BY AGE GROUP

Age group (years)	Sample	Treatment needed				
		Fillings %	Fillings Mean	Extractions %	Extractions Mean	Immediate care %
3-5	104	43.3	1.4	21.2	0.5	12.5
6	112	68.8	2.4	36.6	1.0	13.4
12	121	47.1	1.0	14.9	0.2	7.4
15-19	120	50.8	1.3	15.0	0.2	12.5
20-29	115	66.1	1.9	40.9	0.8	17.4
30-44	137	59.1	1.6	47.4	1.2	16.1
45-64	106	71.7	2.4	80.2	4.5	21.7
All ages	815	58.0	1.7	36.3	1.2	14.4

Tari dental clinic indicated a relief of pain service (80% of all treatments were tooth extraction) to an average of 220 patients a month. Using the data from Table 4 the mean number of extractions needed per person was 1.2 teeth. If the orderly were to perform 220 extractions per month, 12 months of the year, then it would take 39 years to treat all the people needing extractions in the catchment population.

Treatment needs increased rapidly in the primary dentition. Nearly 70% of the 6 year olds needed fillings and 37% needed extractions. An average of 2.4 fillings and 1 extraction per child was needed in this age group.

In the adult sample the overall need for treatment increased with age. The average subject in the 15-19 year age group needed 1.3 fillings, and over half in this age group needed one or more fillings. By the age of 45-64 years over 70% needed fillings, with a mean of 2.4 teeth per subject requiring treatment.

Tooth extraction requirements were more strongly influenced by age, with 15% of the 15-19 year and 80% of the 45-64 year age groups needing extractions. The mean number of teeth needing extraction per subject also showed a dramatic increase (nearly 20 times) from 0.2 teeth in the 15-19 year olds to 4.5 teeth in the 45-64 year age group.

The treatment needs classification allowed for the recording of extractions needed due to severe periodontal disease. These were few in number, with 28 people from the dentate (with teeth) sample of 812 needing a total of 54 extractions (0.07 teeth per person) for periodontal disease. The greatest need was in the older age group, with 21% of the 45-64 year olds needing one or more teeth extracted due to terminal periodontal disease. A few extractions were also needed for other reasons, such as trauma and impacted teeth (0.02 teeth per person) and prosthetics (0.06 teeth per person).

Periodontal disease

The Community Periodontal Index of Treatment Needs (CPITN) was used to assess the periodontal conditions and treatment needs (16). The assessment was made for permanent teeth only, and no periodontal pocket probing was attempted for the 6 year age group. Subjects with no teeth or with all remaining teeth indicated for extraction were excluded.

The main types of periodontal disease are chronic marginal gingivitis and chronic adult periodontitis. When undisturbed dental plaque has been present around the gum margins of teeth for long enough, the gums become inflamed and bleed when touched with a probe (gingivitis). With time, the plaque may become calcified from the minerals in saliva, and this calculus can only be effectively removed by a trained dental worker. In some people, the inflammation spreads deeper into the periodontal (tooth supporting) tissues. Progressive periodontal disease includes gingival recession and/or pocketing, bone loss and eventual loosening of the teeth in more severe cases. Once pockets have developed, the control of the disease is more complex and requires specialized care to halt its progress.

Table 5 shows that almost everyone had some kind of periodontal condition, with only 2.2% of the total sample recorded as healthy (score 0). The progression of the severity of periodontal conditions with increasing age can be seen in the table.

At age 15-19 years only one person had no signs of periodontal disease. About one-third had bleeding as the worst score (score 1) and 63% had calculus as the worst score (score 2). This age group is an indicator age group for international comparisons, and the WHO goal for 15-19 year olds in the Western Pacific was that 25% or less would have a CPITN score of 2 (10). Thus Tari adolescents exhibited considerably worse periodontal conditions than the recommended goal.

The full impact of a lifetime of periodontal neglect was evident in the oldest age group (mean age 52 years). All subjects had some kind of periodontal disease, and 16% had deep pockets indicating moderate to severe bone loss around the affected teeth.

Although the presence of completely healthy mouths was a rarity, very few individuals had generalized severe disease. The CPITN estimates the extent of the disease

TABLE 5

PERIODONTAL STATUS: WORST SEVERITY SCORE BY AGE GROUP

Age group (years)	Sample	Highest CPITN score* recorded per person, as a percentage of age group				
		0	1	2	3	4
6	93	12.9	79.6	7.5	0.0	0.0
12	121	1.7	51.2	44.6	2.5	0.0
15-19	120	0.8	33.3	62.5	3.3	0.0
20-29	115	0.0	7.8	66.1	26.1	0.0
30-44	136	0.0	0.0	39.0	53.7	7.3
45-64	95	0.0	0.0	17.9	66.3	15.8
All ages	680	2.2	27.2	41.5	25.4	3.7

CPITN = Community Periodontal Index of Treatment Needs
* Criteria for recording the CPITN scores in descending order of severity are:
4 = Periodontal pocket 6 mm or deeper
3 = Periodontal pocket 4 or 5 mm deep
2 = Calculus (hard deposits on the teeth)
1 = Gum bleeding after gentle probing
0 = None of the above clinical signs (healthy)

based on measurements in six areas or 'sextants', providing a basis for the treatment needs calculations.

Periodontal treatment needs

Almost all the sample needed some type of periodontal care, with 98% needing instruction on methods of improving oral hygiene. Over 70% required calculus removal and tooth cleaning (scale and polish), with a mean of 2.6 sextants per person needing treatment (maximum number of sextants = 6). Older people needed proportionately more periodontal treatment. All those over 30 years needed scaling, with a mean of 4 sextants per person. However, relatively few people needed complex treatment because of deep periodontal pockets. In the 45-64 year age group, 16% needed specialist treatment with a mean of 0.2 sextants per person.

The CPITN was developed to estimate treatment needs, and does not provide a true picture of periodontal status. The cause of tooth loss is an important factor in evaluating the oral health of a population and the CPITN (1982 version) underestimates the full burden of periodontal disease in the community. Once the disease advances beyond the reach of conservative treatment for a number of teeth in a sextant, then the sextant is included in the 'excluded or missing' sextants category as 'teeth indicated for extraction'. The data are then 'lost' in a category which includes sextants with teeth needing extraction for caries or other reasons, and sextants where there were no teeth at all, for any reason. The mean number of missing or excluded sextants per person in the 45-64 year age group was 1.2.

A further limitation of CPITN in evaluating periodontal status is that gingival recession is not recorded, since it cannot be treated by conventional periodontal therapy. Thus in this study people were not recorded as having periodontal disease if the gingival recession (exposure of the root by loss of periodontal tissues and bone loss) was not accompanied by pocketing. This clinical picture of gradually becoming 'long in the tooth' was common for Huli over the age of 30 years, thereby exposing the more vulnerable root surfaces to caries attack. Future oral health studies in PNG need to include measurement of loss of attachment in addition to the CPITN.

Enamel defects (hypoplasia)

An important and significant finding in this study was the high prevalence of defectively formed (hypoplastic) primary teeth, and their subsequent susceptibility to caries attack. The recording of hypoplasia was based on WHO criteria (17) and the epidemiological index of developmental defects of dental enamel (18). The survey results are summarized under the categories of moderate hypoplasia – pitting or grooves in less than 50% of the tooth surface – and severe hypoplasia – pitting or grooves in more than 50% of the tooth surface.

The usual clinical picture was one of a line of brown-stained grooves or pits running across the front surfaces of the upper primary front teeth, approximately mid-way between the gum margin and the tips of the teeth. Hypoplasia was also seen in the primary molars, and some permanent teeth. Previous research suggests that these defects were caused by environmental disturbances (such as illness or nutritional deficiencies) during the period of tooth development (19). The defect is left as a permanent scar on the developing tooth, and its position allows determination of the approximate time period when the systemic upset occurred.

The most prevalent type of hypoplasia seen in Tari children closely resembled the condition linear enamel hypoplasia, seen in children from other developing countries, such as the highlands of Guatemala (20). The chronology of the hypoplasia corresponded to the period of tooth development around the time of birth, plus or minus a few months. Whilst the exact cause of this type of hypoplasia is unclear, various investigators have suggested the synergistic action of malnutrition and infection, leading to low serum calcium levels (21). Both malnutrition and maternal and neonatal illnesses were a common finding in Tari (6,22). Due to the serious and prevalent nature of hypoplasia in the study population, further multidisciplinary research is needed to determine the morbidity and nutritional factors responsible.

The percentage of 216 children aged 3-6 years with one or more primary teeth showing moderate hypoplasia was 68%. Severe hypoplasia, suggesting severe and prolonged disruption of tooth formation, was found in 18% of the primary dentitions (it is possible to have both moderate and severe hypoplasia in the same mouth). An average of more than 4 teeth per child were affected by moderate or severe hypoplasia. Frequency distribution of the data showed that hypoplasia was more extensive in some children (Table 6).

Permanent teeth were also affected by hypoplasia, especially those formed around the time of birth or shortly afterwards (eg first molars and upper incisors). In the 12 year age group 36% had one or more teeth with moderate hypoplasia, with a mean of 1.6 teeth affected.

TABLE 6

HYPOPLASIA: FREQUENCY DISTRIBUTION OF NUMBER OF PRIMARY TEETH PER CHILD AGED 3-6 YEARS AFFECTED BY MODERATE OR SEVERE HYPOPLASIA

Number of teeth with hypoplasia (per child)	Number of children	Percentage of children
0	62	29
1-4	63	29
5-9	64	30
10+	27	12
Total	216	100

Hypoplasia and caries

Apart from looking bad and being difficult to treat, hypoplastic teeth were also found to be much more susceptible to caries. The pitted surfaces and poor-quality enamel allowed plaque to accumulate and caries to develop. Dietary factors promote or accelerate the process, and sweetened infant feeding supplements and prolonged and unrestricted breastfeeding are known risk factors (12). Prolonged breastfeeding was a common practice in Tari. Sweet fluids, sugar cane and sweet potato are also contributing factors for the higher levels of caries in hypoplastic teeth.

TABLE 7

HYPOPLASIA AND CARIES IN PRIMARY TEETH

Tooth condition	Number of teeth	Number of teeth with caries	Teeth with caries (%)
No hypoplasia	2756	145	5
Opacity*	128	12	9
Moderate hypoplasia	748	248	33
Severe hypoplasia	190	111	58
Total	3822	516	14

*Opacity – white or discoloured opaque area; not associated with hypoplasia, and not resembling enamel fluorosis

Table 7 shows significantly higher caries prevalence in hypoplastic primary teeth (χ^2 = 646; p<0.001; one degree of freedom). Chi-squared trend tests also demonstrate that severely hypoplastic teeth were significantly more likely to develop caries than those with moderate hypoplasia.

Hypoplasia was first reported in PNG in 1935 by Kirkpatrick (23), who used the term odontoclasia, or caries in hypoplastic teeth. Odontoclasia was observed in 22% of Manus Island children aged 6 years or less. The Tari sample of children aged 3-6 years showed that 40% had caries associated with hypoplasia. Subsequent oral health surveys in PNG have linked hypoplasia to increased caries experience in young children (4). The prevalence and severity of hypoplasia in the Tari population was high when compared with both other PNG and international data (24).

Oral mucosa conditions and oral habits

The most important oral mucosa condition seen was the presence of white patches on the inner surface of the cheeks, thought to be caused by irritants such as tobacco smoking, alcohol and betelnut chewing. Over 12% of the sample aged 15-64 years had white patches, although the prevalence was strongly affected by age and sex. The highest prevalence was found in males aged 20-44 years, and 28% of these had white patches. Very few females had this condition. However, the validity of the data on white patches is reduced due to the grouping together of leukoplakia and leukoedema.

The distribution of oral habits was affected by age and sex. Over the total adult sample aged 15-64 years of 478, 57% of males and 28% of females were smokers (mostly home-grown bush tobacco or coarse trade store tobacco rolled in used newspaper). Smoking was most common in males aged 20-44 years (74%). Betelnut chewing, usually with lime and pepper, showed a similar distribution. In the 15-64 year age groups, 22% of males and 3% of females chewed betelnut. Chewing was most common in males aged 20-29 years (53%). No females were recorded as drinking alcohol (beer), but 20% of males aged 15-64 years, and nearly half of the males aged 20-29 years, said that they drank beer occasionally.

Preliminary analysis showed that male smokers aged 30-44 years had significantly more white patches than non-smokers (χ^2 = 16; p<0.001; one degree of freedom). Betel chewers had more white patches than non-chewers, but the association was not statistically significant.

White patches were an important clinical finding because in some people they progress to oral cancer (25). Oral cancer is rare, but those affected often delay in presenting, making cure or rehabilitation difficult. No cancer was seen in the study group.

Betelnut chewing increases the risk of oral cancer (one of the commonest cancers in

PNG), especially when combined with smoking and alcohol as synergists (26). The incidence of oral cancer is on the increase in PNG, especially in the highlands (27). In the last few decades betelnut and beer have become popular in the highlands, joining smoking as co-irritants. The authors of a recent AusAID-sponsored report on cancer in PNG (28) estimate that the latency for the development of cancer from betelnut chewing is about 25 years, and suggest that "the epidemic of head and neck cancers from betelnut in the highlands is just beginning" (28:25).

Comparison of oral health status between Tari and Brisbane

The oral health of the Huli differed from that found in a contemporary population study in Brisbane, Australia (29). The Brisbane group had no exposure to fluoridated water supplies, but had benefited from other preventive methods including fluoride toothpaste, oral health awareness and access to dental treatment.

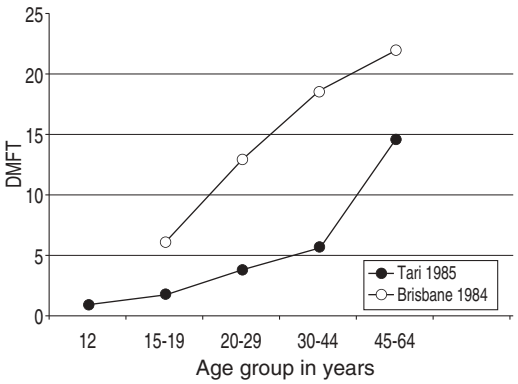

Figure 2. Mean numbers of Decayed, Missing and Filled Teeth per dentate person in Tari and Brisbane, 1984-1985. Brisbane data from Powell and McEniery (29).

The recommended fluoride level in water for optimum caries protection is 1 part per million. The Huli people had access to suboptimal fluoride levels (0.03 parts per million; standard deviation = 0.012) measured at 18 drinking water sources throughout the study area. The oral hygiene of the study group was poor, with about 60% not attempting any form of tooth cleaning. Sugar cane skin or betelnut husk was used by 20%, and a further 20% used a toothbrush occasionally, usually with soap rather than toothpaste.

Figure 2 compares the caries index DMFT and shows that Brisbane had a higher score. A large proportion of the Brisbane DMFT score was due to dental treatment (fillings and extractions). The Huli group had a lower DMFT score especially in the younger age groups. The graph rises steeply for the 45-64 year age group, mainly due to the effect of root surface caries. The level of untreated disease was higher in Tari, shown as decayed teeth in Table 8.

For dentate (with teeth) subjects the Australian group had 60% of the DMFT score as fillings, while the Huli group had 1.6% of the DMFT as fillings (Table 8). The only permanent fillings recorded had been

TABLE 8

COMPARISON OF DMFT SCORES BETWEEN TARI AND BRISBANE DENTATE ADULTS

Age group (years)	Sample	Decayed	Missing	Filled	DMFT
Tari					
15-64	475	3.2	2.9	0.1	6.2
Brisbane					
15-65+	1405	0.9	5.4	9.6	15.9

Brisbane data from Powell and McEniery (29)

performed by the school dental service, or at clinics outside Tari District.

Only 3 Hulis (0.6% of the 15-64 year age group) had no teeth, whereas 286 (17% of the 15-65+ year age group) had no teeth in Brisbane. In some western populations, tooth loss has been shown to be more closely related to the frequency of dental treatment than to actual caries levels. In simple terms, this means that more dentists provide more treatment, resulting in greater tooth loss (13). The DMFT of the Brisbane group may also have included teeth filled for cosmetic reasons, and this is a shortcoming of the index when it is used in populations experiencing a high level of dental treatment.

Periodontal health was poorer in the Huli people in all age groups, as measured by the CPITN. In the 15-19 year age group, less than 1% had healthy periodontal tissues (CPITN score 0 in Table 5). In contrast, 37% of the Brisbane people in the 15-19 year age group had a CPITN score of 0. With increasing age, the prevalence and severity of periodontal conditions was greater for the Huli group. Pockets of 6 mm or deeper (CPITN score 4) were found in 16% of Hulis aged 45-64 years, and in 4-7% of the Brisbane residents in the same age range.

Treatment options for people with dental problems

Modern dentistry

Access to and availability of modern preventive and curative dental treatment in Tari is limited. In 1985 one dental orderly was providing relief of pain services (extractions and temporary dressings) at the dental clinic at Tari Major Health Centre. The electric dental drill had been out of service for two years. Occasional power cuts, lack of anaesthetic, or the absence of the dental orderly, meant that needy patients were turned away. Some were treated with aspirin or antibiotics at the outpatients clinic, and others sought traditional remedies and extractions back in the community.

Schoolchildren had the additional benefit of treatment and health promotion through the school dental service. Although the provision of oral health care to schoolchildren was the first priority of the dental services in the 1980s, the coverage rate in Southern Highlands Province (SHP) was low – about half the national average. In 1984 only 15% of schoolchildren in SHP had been reached by a dental worker (30). Only high schools in Tari had been visited by the school dental service since 1981.

Schoolchildren were keen to learn the dental health message, which formed part of the school curriculum. The survey team visited a number of community schools, with over 1400 students participating in oral hygiene practicals. Supervised brushing programs were started at the schools using kits supplied by Colgate Palmolive, Port Moresby.

The difficulties in providing health services to remote rural areas from a centralized and often distant provincial headquarters are great. A number of oral health reports in PNG endorse the value of a primary health care approach, which includes community participation, an accent on prevention and appropriate treatment at the aid post level (31,32). In Southern Highlands Province selected aid post orderlies (APOs) and more recently community health workers (CHWs) have received basic training in the diagnosis, referral and treatment of common oral diseases (33,34).

Dentally trained community health workers could also be a valuable part of the health team in rural communities. Given suitable training and support, they could perform simple extractions, treat dental pain and infection and restore many teeth with the atraumatic restorative technique (ART) using hand instruments, with no drill or anaesthetic. Dentally trained CHWs are well positioned in the community to assist with health education in schools and other institutions.

However, achieving these conditions will not be easy. The supervision, support and evaluation of the dentally trained APOs in Tari was poor in 1985. Two of the five dentally trained APOs in Tari District were contacted and interviewed during the survey. One had left the Department of Health to pursue a

career in politics, and his replacement was unsure how to use the instruments. The other complained of lack of feedback from dental workers in Mendi, lack of local anaesthetic, lack of confidence, and a broken syringe. Consequently he was not extracting teeth.

Traditional methods

The Huli are pragmatic in their choice of treatment options, and will use home care and traditional remedies in addition to introduced modern medicine (35). Distance from Tari dental clinic was an important variable in past treatment histories. Significantly more older adults in the hills environmental zone, 3 hours walk away, had experienced tooth extraction by traditional means than in the other areas with better access to the clinic.

Pain and blood were closely related in the traditional Huli concepts of pathology. A number of respondents to the interview-questionnaire reported that they had tried to release the 'bad blood' causing their toothache, using a sharpened stick or piece of bone to cut the gum adjacent to the affected tooth. This approach is similar to the modern technique of incision and drainage of an abscess.

The preferred dental instrument of the five traditional practitioners interviewed at Tari was a six-inch nail, suitably shaped and sharpened and fitted with a cloth or bark handle bound with string. The instrument closely resembles a modern dental elevator, and was used in a similar way to extract teeth, although no anaesthetic was used. Mostly older adults (69 people in total) had experienced traditional tooth extraction. This represented 24% of all past tooth extraction treatments.

Home care remedies were related to an individual's belief in the cause of their dental problems. Traditional beliefs in sorcery, toothache spells and compensation payment difficulties were being overtaken by Christian prayer and a resort to aid post medicines. Some local herbal toothache remedies and adapted methods included nettles used as a counter-irritant, hot sweet potato, and wads of hot leaves or ginger held over a sore tooth. Aromatic bark (*Cinnamomum* sp.) was sucked on to relieve toothache, and the resinous residue of the smoking pipes (*Nicotiana tabacum*) was placed into decayed teeth. Betelnut was claimed to make the mouth feel fresh, and was said to prevent or cure toothache.

Many Huli believed that tooth decay was caused by a smaller version of *pubu*, the wood-boring grub. The white sap of the fish-stunning shrub *Euphorbia plumerioides* was used to kill maggots in tropical ulcers (35). A number of people surveyed had also used the sap to kill the *pubu* they thought were the cause of pain in their teeth. They claimed the poisonous sap gave pain relief for up to three months. An insecticide ointment introduced to treat screw worm in cattle was also tried for tropical ulcers and to control the *pubu* in cavities, and was said to kill the pain instantly. The wider health implications of the above methods were not evaluated during the present study.

Conclusion

Oral health overlaps with other areas of health care and community welfare. The emergence of lifestyle diseases, representing a transition from traditional rural life to more modern ways, adds to the risk of new disease patterns. The increase in the prevalence and severity of caries (tooth decay) has been demonstrated for many populations in developing countries in transition from rural to urban lifestyles. Dietary change with more refined foods, soft drinks and sugar are linked to a number of health risks, including increased caries. There is a wealth of information to assist people towards good oral health, but as yet this message has not reached the vast majority of the population. It appears that healthy preventive behaviour is lagging behind dietary changes and a love of sweet things.

Preventive health attitudes and behaviours will have to compete with the clamour of commercial advertising, often promoting items which are bad for oral health. School groups would be an ideal nucleus to create the growth of oral health awareness in a community. Treatment of dental problems is best provided at a local level, close to people's homes. In rural areas which are distant from reliable facilities, the provision of dental treatment is difficult. The atraumatic restorative technique

mentioned earlier in this paper would serve as a good basis for minimum-intervention, low-cost, high-gain dentistry in these remote areas.

The Tari oral health survey measured a wide variety of oral health parameters and social and economic factors thought to influence oral health. This paper summarizes the most important findings and outlines the oral health profile of a rural highlands community in 1985. Interpretation of the results yields answers to the question, "Just how good were the teeth of the Huli?"

There was considerable untreated disease in the population, with two-thirds of the sample having one or more decayed teeth. The older age groups had more caries, and over half of the people in the 45-64 year age group complained of pain or holes in the teeth during the interview. Caries and dental infections were common in the primary dentition, with developmental tooth defects (hypoplasia), thought to be caused by illness and/or malnutrition, an important finding.

The younger adults and children with permanent teeth generally had good mouths and lower caries rates by international standards. However, the commonly occurring periodontal diseases, gingivitis and chronic adult periodontitis, were common and started early in the study population. By 15-19 years of age 63% of these teenagers had calculus or bleeding gums. Oral hygiene instruction, including regular flossing, and a scale and polish are the recommended treatments. Due to poor oral hygiene, periodontal irritation often leads to gum recession, bone loss and exposure of the softer root surfaces to the risk of root caries. Root surface caries was a major factor in the progress of caries in the older age groups. Many older adults had teeth which had fractured to the gum line, with the retained roots continuing to be functional during chewing.

Oral habits affect the oral health of the study population. Tobacco smokers have worse oral hygiene and an increase in the prevalence and severity of periodontitis compared to non-smokers (36). In Tari the adult males were the heaviest smokers, and had the worst oral health of the sample. Very few females smoked, and they were seen to have uniformly better oral health than males. Betelnut chewers had more leukoplakia than non-chewers, but the statistical association was weak.

Comparing the oral health profiles from Tari and Brisbane reveals a number of differences. Whilst DMFT scores in Brisbane were higher, the Huli population had a higher level of untreated dental caries. Periodontal health was poorer for the Huli in all age groups. Totals for the 15-65+ year age groups revealed that 17% of the Brisbane sample were edentulous (no teeth), whereas only 3 people (0.6%) in the Tari sample had no teeth. The Brisbane population had experienced a higher level of dental treatment.

Many people do not look into their own mouths. Often they have no idea that a problem is developing and benefit from someone else looking and diagnosing. Regular check-ups by dental workers help to control oral disease and promote good health. Once preventive behaviour has been established, and the oral disease rate evaluated, monitored and stabilized, it is clear that many people can enjoy good oral health for life. Short-term gains in oral hygiene following school talks need to be followed up in a supportive home environment.

Access to dental services, or the choice of service, is limited in many areas of Papua New Guinea. In 1985 the Huli of the Tari Basin resorted to a number of treatment options, including traditional spells and herbal remedies, local people providing extraction services with a six-inch nail, and treatment at the dental clinic at Tari hospital. Current staffing levels in the oral health service of the national Department of Health are low, and approximately half of the provinces are without a resident dental surgeon. Dentists are being trained in Fiji and Australia, but there is also a critical shortage of dental technicians.

The simple prevention and treatment of basic dental disease at the rural level would require excellent national and provincial management and public health skills, considerable resources, and a restructuring of the method of delivery of dental services at the village level. The dental therapists continue to

be the backbone of the oral health service in PNG, but they are increasingly being asked to provide more complex clinical and administrative skills beyond their level of training. More dental workers are needed, at both senior and grass roots levels.

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